ITS SERVICE BOOK

ITS903 FREEWAY RAMP METERING

Purpose

Ramp Metering Systems (RMS) provides the ability to control access to a freeway to help improve overall corridor mobility. A platoon of vehicles entering freeways during peak periods has a significant impact on traffic flow by creating lane speed differentials and volume surges resulting in decreased overall speed.

RMS use traffic signal heads integrated with local traffic detectors through a ramp-metering controller. During operation, a red stoplight makes a driver stop at the stop bar for a pre-determined time period based on local traffic conditions and parameters (e.g. 6 seconds). Then, upon switching momentarily to green light, the stopped vehicle proceeds. The signal head then returns to red light for the next vehicle.

RMS can be deployed across most ramp types, but sufficient storage must be available to avoid queues extending on to adjacent roadways. Furthermore, RMS is typically deployed along successive ramps on a corridor rather than at one interchange.

The objectives of RMS are to:

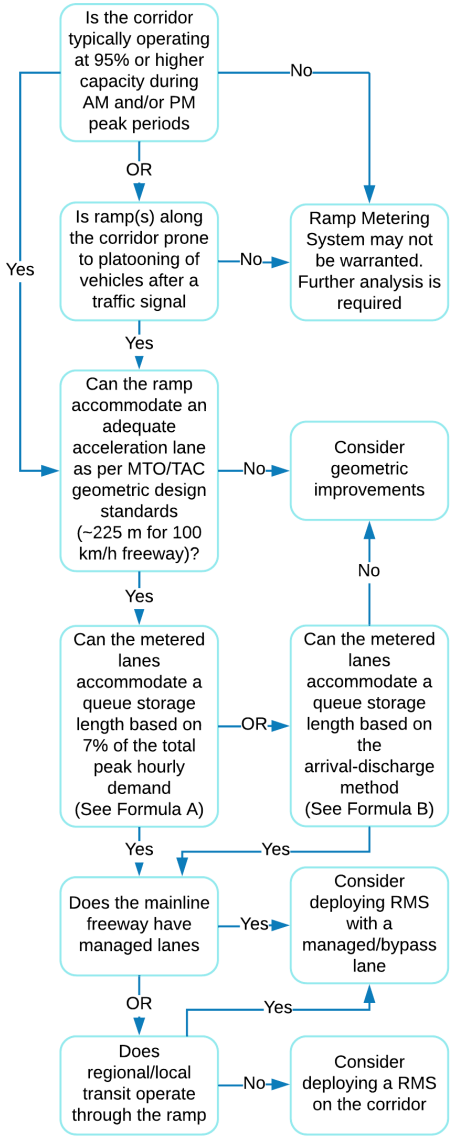
- Improve safety by minimizing sideswipes and rear-end collisions that may result from groups of vehicles merging creating lane speed differentials
- Optimize travel time along the mainline during peak conditions

Key benefits include:

- Increase in average traffic speed on the mainline freeway
- Increase in vehicle throughput on the mainline
- Reduction in travel time on the mainline freeway
- Reduction in collisions
- Reduction in emissions

Considerations for Use

The following decision tree provides a reference for considering Ramp Metering Systems on Ontario freeways.



Formula A:

$$\frac{7\% \times VPH \times 8.8\ m/veh}{\#\ of\ metered\ lanes}$$

Where VPH = total peak vehicles per hour

Formula B:

Refer to Appendix D: Arrival-Discharge Chart Method, Caltrans Ramp Metering Design Manual, April 2016
www.dot.ca.gov/trafficops/tech/docs/RMDM.pdf

ITS Service Applicability and Limitations of this Service Book

This Service Book may be used in conjunction with other related MTO ITS Services that may have Service Books associated with them.

- ITS201 – Planning Data
- ITS502 – Traffic Signal Pre-Emption for First Responders
- ITS601 – Traffic Signal Pre-Emption for Transit
- ITS901 – Traffic Signal Control
- ITS902 – Connected Vehicle Traffic Signal System
- ITS921 – Roadway Closure Management

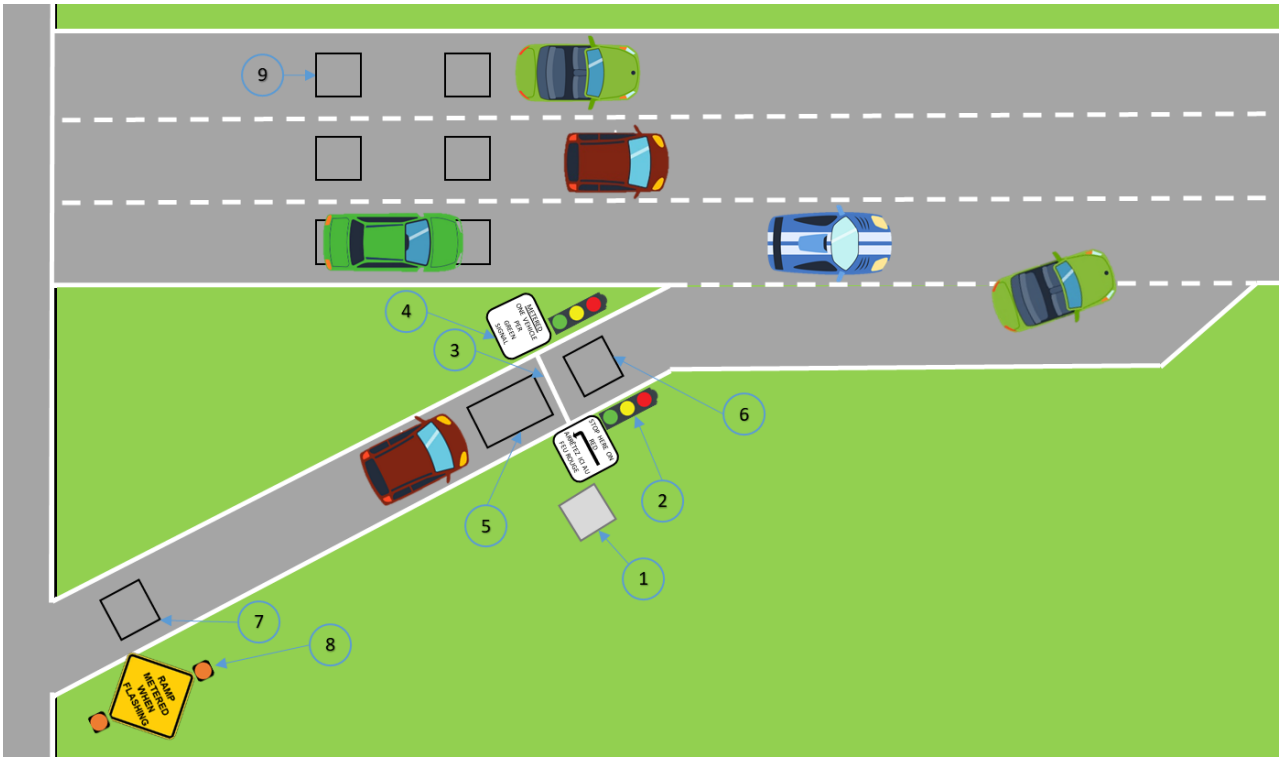
Limitations

This Service Book may be used in conjunction with other Service Books that have been developed.

This Service Book will aid in determining the need, components, purpose and general placement for a Ramp Metering System. Further analysis, specific to the application, is encouraged.

This Service Book focuses on inductive loop-based systems currently deployed by the MTO.

While technologies and data sources continue to evolve, this Service Book references technologies open to using by the MTO.



System Components

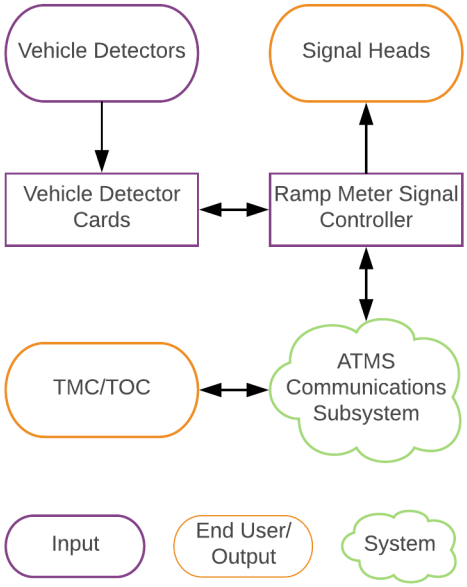
The key components of a Ramp Metering System are detailed in the following diagram:

1. **Ramp Metering Controller –** Cabinet enclosure housing the ramp signal controllers, loop detectors cards, and metering software
2. **Ramp Control Signals –** two (2) signal heads, one on each side of the ramp providing guidance on when to stop and when to proceed. The right-side signal is typically installed at 2.75 m height while the left side is installed at 1.0 m.
3. **Stopbar –** pavement marking denoting the location where the vehicle should stop. This should be strategically placed based on the acceleration lane length downstream and the queue storage requirements upstream.
4. **Signage –** signage providing instruction on how to use the RMS
5. **Demand Loop –** determines if a vehicle is present using a loop immediately upstream of the stop bar
6. **Passage Loop –** determines if a vehicle has been released from the metered queue
7. **Queue Loop –** determines if a queue length has reached the storage limit, vehicles queuing beyond this point would directly impact traffic on the connecting roadway. Typically located at the arterial ramp bullnose.
8. **Advance Warning Sign** provides advance notification that the RMS is active.
9. **Mainline loops –** mainline vehicle detection for volume and speed counts to determine the level of service on the mainline and the need for ramp metering (i.e. LOS D or below). Typically located 50-100 metres upstream of the freeway-ramp bullnose.

Architecture

The following architecture provides an overview of the system components and their interactions along with the information flow.

Conditions are monitored by the ramp metering software and, based on time of day and/or traffic counts/speeds from the vehicle detectors, determines when to activate the ramp metering station and its associated traffic signal heads.



Traffic Management

A Ramp Metering System can operate autonomously but there may be justification to have corridor responsive RMS where traffic count data from upstream and downstream along the mainline, exit and entrance ramps affect how the system functions.

Furthermore, loop detectors deployed for RMS may be leveraged for other traffic data analysis.

Deployment Considerations

The following are some considerations as part of the deployment of an RMS:

- Non-intrusive detection options may be considered instead of inductive loops
- Consider the number and types of lanes in the configuration
  - Single-lane ramp
  - Dual-lane ramp
  - 1 single + 1 managed lane
- Take into consideration the ramp acceleration length, queue storage length, and stop bar signal head sight distances when placing the stop bar
- Place traffic signal heads on each side of the road approximately 3 m downstream of the stop bar
- Consider placing the controller cabinet on the inner side of the ramp curve in view of the stop

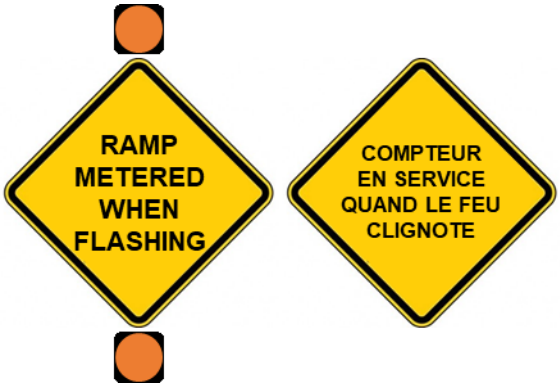
bar and signal heads to support maintenance activities

- Consider providing a maintenance access area around the ramp
- Consider providing an enforcement area downstream of the stop bar for OPP to park vehicles
- Consider advance warning for ramps, which may have limited sightlines to the stop line. Advance warning may consist of static signage with flasher beacons "Ramp Metered When Flashing"
- Consider inclement weather and special events in the operation
- Engage external stakeholders such as municipal transportation authorities when planning for RMS
- Consider public education programs to educate users on proper compliance and inform of the benefits of RMS
- Refer to MTO/OPS standards for additional design guidelines
- Consider bilingual signage requirements depending on the installation location

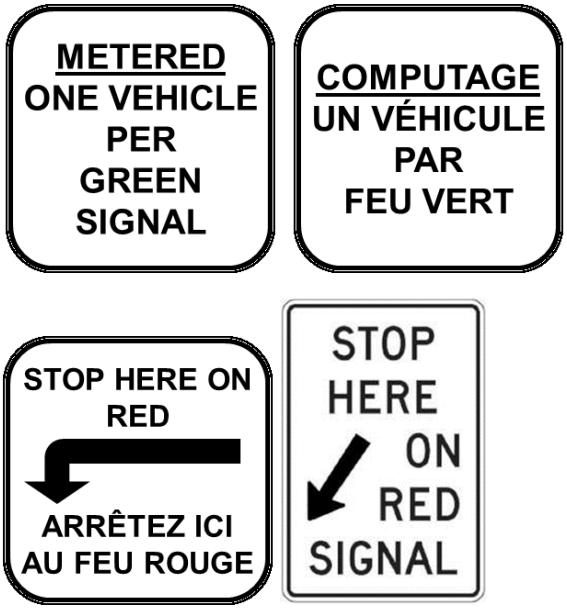
Messaging Examples

Examples of supporting signage are shown within this section

Advanced Warning Signs



Static Signage at Meter



Costs and Procurement Strategy

Budgetary costs are provided below for system components. A combination of the components can help to provide an estimate for a specific application.

However, there may be additional costs to integrate the Ramp Metering System to MTO's TMC/TOC Operations and associated systems.

Refer to HiCo for additional details and regional estimates.

Element	Cost (2019)
Purchase: Supply and Install	
Loop Detectors	$1,500
Loop Detector Cards	$500
Steel Pole	$2,000
RMS Controller Cabinet Site	$30,000
Advance Warning Sign with Flasher Beacons	$3,000
Static Signage and Pavement Markings	$1,000
ATMS Field Cabinet Maintenance Site	$12,000

Element	Cost (2019)
Solar Power Kit (for advance	$3,000
Cellular Modem	$1,000
Civil Provisions (Ducts, F/O, Power)	$150,000 per km
Traffic Control (per lane closure)	$4,000
Operations and Maintenance	
Maintenance of signs, cabinets, signals, etc.	~10% of capital/year

Sample Cost Deployment

An example of a Ramp Metering System for a single-lane ramp on a three-lane freeway may consist of:

- Loop Detectors
  - 1 x $1,500 = $1,500 (Queue loop)
  - 2 x $1,500 = $3,000 (Demand loops)
  - 1 x $1,500 = $1,500 (Passage loop)
  - 6 x $1,500 = $9,000 (Mainline loop)
  - 3 x $500 = $1,500 (Detector cards)
- Ramp Metering Controller Site
  - 1 x $30,000 = $30,000 (Controller w/ Cabinet)
  - 1 x $12,000 = $12,000 (Maintenance access)
- Metering Signals
  - 2 x $3,000 = $6,000 (signal heads)
  - 2 x $2,000 = $4,000 (steel poles)
- Signage and pavement markings
  - 1 x $1,000 = $1,000 (static sign, pavement markings)
  - 1 x $3,000 = $3,000 (advance warning sign)
- Power, Communications, and Civil
  - $15,000 (miscellaneous civil works)
- Total Deployment = $87,500

System Life Cycle

The expected life cycle may range from 10 to 15 years depending on the configuration.

The mean time between failures (MTBF) of relevant equipment for planning, and rehabilitation purposes:

- RMS Controller – 15 years+
- Civil Provisions – 25+ years
- Controller Cabinet – 25+ years
- F/O Cable – 25+ years
- Network Switch – 15 years+
- Non-intrusive Traffic Sensor – 5 years
- Poles – 25 years+
- Portable VMS – 5 years
- Ramp Metering Signals – 15 years+

Case Studies/Previous Deployments

Description	Components
Ramp Metering System Ministry of Transportation Ontario	• Deployed along the QEW, primarily in Mississauga • Algorithm recently upgraded
Ramp Metering Systems Various US DOTs	• Significant deployments across USA • 15 to 50% reduction in collisions • Public acceptance varies

Performance Measures

- Average travel time (on mainline) during RMS operation
- Average speed (on mainline) during RMS operation
- Number of collisions during RMS operation

Emerging/Alternative Technologies

This section details emerging technologies and/or alternative technologies not currently supported by the MTO.

- Corridor Adaptive RMS – conditions across the entire corridor affect local RMS operation as opposed to an independent system at each ramp site.
- Non-intrusive vehicle detection – Solutions available instead of inductive loops using roadside radar detectors
- Optically programmable signal heads – Select deployments utilizing two sets of signal heads, one for vehicles approaching the stop bar, and

an optically programmed head for drivers at the stop bar to help avoid confusion